Insulation material element made of mineral fiber felt for clamping-like assembly between beams and the like

The present invention refers to an insulation material element, according to preamble of claim 1.

Such a "clamping felt" is known, for example, from DE 36 12 857 and is being successfully used for many years, especially for insulation purposes between rafters in vertical roofs. For this purpose, a glass wool felt is being used, whose fibers are being obtained by internal centrifugation, according to the centrifuging basket process, bound with a binding agent quantity of approximately 6 to 7 weight % (dried, relative to the fiber mass), which is increased with respect to conventional glass wool, and the gross densities with nominal thickness of such insulating material sheets produced is between 10 and 30 kg/m3. For transportation and warehousing, the felt sheet produced is rolled up with an average compression of 1:5 as a roll felt and, compressed in this fashion, it is being packed in a foil. At the construction site, the foil is cut and the roll felt, as a result of its internal tension, rolls out in the form of a plane insulating material sheet with plate-like character, in a certain nominal thickness. From this rolled out insulating material sheet, normally supported by marking lines foreseen transversally to the longitudinal direction of said insulating material sheet, it is possible to cut off plates corresponding to the local width of a rafter area, which are then being mounted into said rafter area transversally towards the production and roll up direction ("The plate from the roll"). The cutting procedure takes place with a certain excessive measure, so that during introduction into the rafter area, the plate segment is laterally compressed against the rafters, which is reinforced by the relatively high tensions then arising inside the clamping felt, in the form of clamping forces, which, by friction at the contiguous rafter area, avoid falling of said plate segment. From this clamped assembly originates the expression "clamping felt". Optionally to the insulation material sheet there are also insulating plates made of mineral wool and being clamped between rafters available that feature marking lines, which serve here as a cutting aid for inserting the insulation material plates between the rafters.

In order to insure, between the rafters, a corresponding clamping effect of the insulating material plates cut off from the rolled insulating material sheet, it is required that these insulating material plates, cut off excessively, during their assembly between the rafters,

feature correspondingly high clamping forces. For this purpose, these clamping felts are being configured with high rigidity, which is attained due to the fact that these glass wool felts are being produced with a relatively high binding agent content, which is approximately between 6 and 7 weight %. Due to this high binding agent content, on the other hand, a correspondingly high integration of fire load is produced, which, again, is disadvantageous from the viewpoint of technical fire protection reasons.

Although such clamping felts are being widely used, additional improvements are desirable. Said roll felt sheet also has to be manufactured with a certain excessive thickness, in order to insure that after rolling out, the sheet effectively attains the nominal thickness, required for assembly of the clamping felt plates. It must be observed, in this case, that opening of the roll does not take place immediately after packing, but after a warehousing period at the manufacturer, in the shop or consumer, comprising weeks or months. During this period, the internal tension of the material may progressively be lessened, as a result of aging factors, so that the insulating material sheet for the clamping felt, when being rolled out, does not recover its original thickness as desired, as would occur when the roll is immediately opened after its production. This possibly reduced resetting feature with the passage of time is being considered by am excessive thickness during the production phase. This excessive thickness, which in addition to aging phenomena, also considers a partial fragmentation of fibers during the roll up procedure, as a consequence of the compression feature, is highly important. So, a clamping felt with a nominal thickness of 160 mm, may require a production in a thickness of 200 mm, in order to insure that also months later a resetting to the nominal thickness of 160 mm takes place surely.

On the other hand, also clamping felts of rock wool are known (DE 199 104 167), with the rock wool being produced in the so called nozzle blowing process or by means of other centrifuging, eventually with the so called cascade centrifuging process. The conventional rock wool fibers thus obtained consist of relatively short, however thick and therefore comparably less elastic fibers with a bead portion, i.e. a portion of not fiberized material of 10 to 30% of the fiber mass. The beads are of non-defibrated material, therefore rougher fiber components. The gross densities of this material are practically above 25 kg/m3, and the binding agent content of these clamping felts of conventional rock wool, compared to clamping felts of glass wool, with eventually 2 to 3 weight %, is relatively low. Nevertheless, as a consequence of the high gross density, seen from an absolute viewpoint, the inte-

gration of binding agent is comparable to the integration which takes places with clamping felts of glass wool. As a consequence of the relatively reduced elasticity, such clamping felts of conventional rock wool, in the way they have to be rolled for transportation in the form of roll felts, before the rolling up station, are eventually recompressed and decompressed, in order to render them more "elastic". With such an elastification by means of application of pressure, however, there will forcibly result a fiber rupture. As a consequence of this event and due to the subsequent strain exerted upon the fibers during the rolling up process, to prepare the roll, a resetting during the roll out phase to form the clamping felt plate, especially with high compression figures, is unsatisfactory and is lower than with conventional glass wool felt.

Based on the relative high gross density of conventional glass wool felt, a compression ratio above 1:2,5 approximately is less practicable, since in this case the mechanical properties of the product would suffer considerably. In addition, with such a compression relationship only a reduced economy of space may be obtained for warehousing and transportation, as compared to glass wool clamping felts.

To attain thermal conductivity group 035 with rock wool material, a gross density of approximately 40 to 45 kg/m3 is required, while with the same thermal conductivity group, with glass wool material, a gross density of less than 20 kg/m3 is being attained. To obtain the same thermal passage resistance, a clamping felt plate of conventional rock wool felt is at least twice as heavy as a plate of conventional glass wool felt, which is negatively observed vis-à-vis the clamping condition, based on the higher specific weight of the rock wool felt.

A characteristic feature of differentiation between glass and rock wool as subgroups of the category of mineral wool, consists in the alkali/earth alkali mass relation of the composition, which in the case of rock wool is < 1 and in the case of glass wool > 1. Typically, conventional rock wool has a high portion of CaO + MgO of 20 to 30 weight % and a relatively low portion of Na2O and K20 of approximately 5 weight %. Typically, conventional glass wool, on its turn, features earth alkali components of approximately 10 weight % and alkali components above 15 weight %. These figures apply especially to non-biopersistent, i.e. biosoluble compositions.

It is an object of the present invention to create a mineral fiber element, particularly a mineral fiber plate from the roll, for clamped assembly between beams, such as roof rafters,

which, vis-à-vis comparable mineral fiber elements from the state of the art, feature a lower fire load between beams, i.e. a lower absolute binding agent content, without affecting the demands of the prevailing fire protection and the clamping behavior, as well as processing, especially haptic, and simultaneously – seen from an absolute viewpoint -the excessive thickness, required during the production of the mineral wool felt to be rolled up, should be reduced.

According to the invention, this task is being solved by the features, contained in the characteristic part of claim 1, and preferred additional embodiments are marked by the characteristics contained in the dependent claims.

The invention is distinguished by an alkali/earth alkali mass relation of the mineral fibers of < 1 and a fine fiber structure of the insulating element, determined by the factors of average geometric fiber diameter ≤ 4 μm, gross density in the range of 8 to 25 kg/m3 and a binding agent portion in the range of 4% to 5,5 weight %, referred to the fiber mass of the insulating material element. Based on the chosen alkali/earth alkali mass relation of < 1, the fibers evidence a high temperature resistance, similar to conventional rock wool fibers. The fine fiber structure is essentially used due to the fact that fibers with an average geometric fiber diameter of ≤ 4 μm are being used. Such a fiber structure may also be attained with glass wool, however as compared to rock wool, it is considerably less temperature resistant. The range of the average geometric diameter of conventional rock wool fibers is normally above 4 to 12 μm, so that the fibers are configured in relatively coarse fashion. As a consequence of the configuration according to the invention, there results for a mineral fiber structure, with identical gross density as in the case of conventional rock wool, a far larger number of fibers in the structure and, therefore, a large number of crossing points of said fibers. Therefore, this structure may be adjusted to a lower gross density, and the gross density range, according to the invention, is from 8 to 25 kg/m3 for the desired usage of the clamping felt. Also the insulating element is distinguished by a satisfactory insulation capacity.

Additionally, also the use of a preferentially organic binding agent may be reduced with the product according to the invention, as compared to glass wool, i.e. to a range of 4 weight % up to 5,5 weight %, preferably to a range of 4,5 weight % until 5 weight %, with which the applied fire load is being reduced, without negatively affecting the clamping behavior. Finally, as a result of the fine fiber structure and reduced fire load the insulation ma-

terial element is sufficiently stiff. In the case of an insulation material sheet this is at the same time windable up to a roll without damaging the fibers. The insular mineral fiber plate, cut off from the roll, is thereby sufficiently rigid for clamped integration between beams, i.e. rafters. As a consequence of the fine fiber structure, as compared to conventional rock wool, the air portion required for the insulation effects, is raised inside the clamping felt, which results in a corresponding increase of the insulating effect. Both the insulation material sheet and the insulation material plate are homogenously formed in the range applicable for the clamping effect, meaning that they feature the same density relations via the cross section.

Compared to conventional rock wool, from the higher, relative binding agent content, a more rigid configuration of the clamping felt results, but as a result of the considerably higher gross density of the conventional rock wool, the applied absolute fire load is being essentially reduced. In an analog fashion, also the fire load is reduced, as compared to conventional clamped felts made of glass wool.

As already initially outlined, the fibers according to the invention distinguish themselves as a result of the alkali/earth alkali mass relation of < 1 by the high temperature resistance and correspond, therefore, to the properties of conventional rock wool. Based on the finer fiber structure, however, and on the comparably lower gross density, there results for the structure according to the invention, a far more elastic behavior. Compared to conventional rock wool, the insulation material sheet, before the roll up step, does not require special treatment, eventually a fulling or flexing process, so that the compression and decompression steps, required with conventional rock wool, are no longer needed. Conveniently, the mineral wool felt, during the roll up phase, is being compressed to a roll with a compression ratio of 1:3 to 1:8, preferably from 1:4 to 1:6.

In a similar fashion, the clamping felt of the invention distinguishes itself by an outstanding resetting behavior, so that the required insulation material element advantageously may be produced with a comparably lower excessive thickness, than this takes place with conventional products. This resetting behavior remains preserved also after longer warehousing periods of the rolled up roll felt, so that the insulation material sheet, when being used, again is being reset advantageously to its nominal thickness, which is important also vis-à-vis the technical insulation features. The term insulation material sheet has to be broadly seen and it comprises a never-ending sheet, as it is coming out of the hardening oven for further mechanical processing, meaning edge-trimming, cut-outs, etc. therefore

also to a roll convertible, meaning rolled insulation material sheets, which can be separated on the site at the right distance to the plates.

The reduction as a result of the required excessive thickness, based on the improved resetting behavior, has advantageous effects at an existing, unaltered production site, since with this feature it is also possible to produce nominal thickness which so far could not be produced without additional investment costs, since the maximum global thickness of the produced felt is composed of nominal thickness and excessive thickness.

In addition, as a consequence of the reduction of the required excessive thickness, the operational safety of the production may be advantageously increased. The limiting parameter is a minimum gross density, technically predetermined by the hardening oven, being defined from the initiating configuration of heterogeneous phenomena in the fleece by the passage flux of hot air during the hardening process. As a consequence of the lower excessive thickness required, with identical fiber mass applied, this is present in a small volume, resulting in higher gross density in the hardening oven, i.e. the reduction of the excessive thickness increase, the so called "safety distance". With the utilization of the "safety distance", thus obtained, this renders it possible to additionally minimize the product gross density, which again results in a lighter product, which may be processed with less fatigue (keyword: shorter assembly times).

Additionally, as compared to conventional rock wool, during the assembly, other advantages become apparent for the product according to the invention. During the assembly between roof rafters, an improved resetting takes place in "lateral direction", due to the fact that most of the fibers are aligned parallel to the large surfaces of the product and, in addition, in this direction, which during the roll up process is radially placed towards the roll up nucleus, practically no fibers are being damaged during the roll up process. The clamping felt is thus quite considerably more rigid in the lateral direction than eventually in its "thick" direction. It has been evidenced that this lateral clamping force during the assembly, in the case of the product according to the invention, does not notably decline with the passage of time, which evidently may be attributed to the improved elasticity properties of the product according to the invention, also exposed to aging influences.

For embodiments according to practical usage, work is being accomplished with a gross density in the range of 8 to 14 kg/m3, preferably 11 to 14 kg/m3, especially approximately 13 kg/m3, and with such gross densities, thermal conducting capacity results, corresponding to

the thermal conductivity group 040 according to DIN 18165 or similar, are being attained. By adjusting to a thermal conducting capacity corresponding to thermal conductivity group 035, according to DIN 18165 or similar, a gross density of 18 to 25 kg/m3, preferably from 19 to 24 kg/m3, especially approximately 23 kg/m3, will be required. For clarification it has to be adhered that references to DIN-norms and examination requirements respectively refer to the current version to the filing date.

With the clamping felt of the invention it is also possible to attain fire protection constructions of at least a fire resistance category EI 30 according to EN 131501, where the clamping felt is integrated between beams, such as roof rafters, without additional interior lining.

The mineral fibers for the insulation material of the invention may especially be produced by internal centrifugation according to the centrifuging basket procedure, with a temperature at the centrifuging basket of at least 1.100 °C, with the obtention of fibers with a fine fiber diameter in the indicated range. Mineral wool fibers, produced with the internal centrifugation according to the centrifuging basket process, are known from EP 0 551 476, EP 0 583 792, WO 94/04468, as well as from US 6,284,684, to which reference is expressly being made with a view to additional details.

The reduced average geometric diameter, responsible for the fiber fineness, is being determined by the frequency distribution of the fiber diameter. The frequency distribution can be determined with the microscope, based on a wool sample. The diameter of a large number of fibers is being measured and applied, resulting in an oblique distribution towards the left side (see Figures 2, 3 and 4).

With a view to the temperature resistance, it is convenient, in the case, that the insulating element feature a fusion point according to DIN 4102, Part 17, of $\geq$ 1.000 ° C.

Advantageously, the clamping felts are formed of mineral fibers, soluble in physiological milieu, corresponding to the requirements of the European Guideline 97/69/EG and/or the requirements of the German Dangerous Products Norm, Section IV, Nr. 22, insuring absence of dangers to the health of the clamped felts during their production, processing, utilization and elimination.

Subsequently, in Table 1, the preferred composition of the mineral fibers of a clamping felt according to the invention is shown, per range, in weight %:

Table 1

SiO_2	39 – 55 %	preferably	39 – 52 %
Al_2O_3	16 – 27 %	preferably	16 - 26 %
CaO	6 – 20 %	preferably	8 - 18 %
MgO	1 - 5 %	preferably	1 – 4,9 %
Na_2O	0 - 15 %	preferably	2 - 12 %
K_2O	0 - 15 %	preferably	2 - 12 %
R_2O ($Na_2O + K_2O$)	10 – 14,7 %	preferably	10 – 13,5 %
P_2O_5	0 - 3 %	preferably	0 - 2 %
Fe_2O_3 (iron total)	1,5 - 15 %	preferably	3,2 - 8 %
B_2O_3	0 - 2 %	preferably	0 - 1 %
TiO_2	0 - 2 %	preferably	0,4 - 1 %
Other	0 – 2,0 %		

A preferred smaller range of SiO_2 is 39-44 %, particularly 40-43 %. A preferred smaller range for CaO is 9,5-20 %, particularly 10-18 %.

The composition according to the invention relies on the combination of a high Al_2O_3-content, of between 16 and 27 %, preferably greater than 17 % and/or preferably less than 25 %, for a sum of the network-forming elements – SiO_2 and Al_2O_3 – of between 57 and 75 %, preferably greater than 60 % and/or preferably less than 72 %, with a quantity of alkali metal (sodium and potassium) oxides (R_2O) that is relatively high but limited to between 10-14,7 %, preferably 10 and 13,5 %, with magnesia in an amount of at least 1 %.

These compositions exhibit remarkably improved behaviour at very high temperature.

Preferably, Al_2O_3 is present in an amount of 17-25 %, particularly 20-25 %, in particular 21-24,5 % and especially around 22-23 or 24 % by weight.

Advantageously, good refractoriness may be obtained by adjusting the magnesia-content, especially to at least 1,5 %, in particular 2 % and preferably 2-5 % and particularly preferably $\geq$ 2,5 % or 3 %. A high magnesia-content has a positive effect which opposes the lowering of viscosity and therefore prevents the material from sintering.

In case Al_2O_3 is present in an amount of at least 22 % by weight, the amount of magnesia is preferably at least 1 %, advantageously around 1-4 %, preferably 1-2 % and in particular 1,2-1,6 %. The content of Al_2O_3 is preferably limited to 25 % in order to preserve a sufficiently low liquidus temperature. When the content of Al_2O_3 is present in a lower amount of for example around 17-22 %, the amount of magnesia is preferably at least 2 %, especially around 2-5 %.

The present invention combines, thus, the advantages of glass wool, relative to insulating capacity and compression, with those of rock wool, relative to temperature resistance and distinguishes itself also by an exceptional and predominant fire protection. Compared to rock wool, also an essential economy of weight is important, which has indirect effects vis-à-vis the clamping insertion technique, since the clamping felts of the invention are practically exempt of beads not participating of the insulation effect, meaning that the bead proportion is < 1%. Due to this the specific load to be retained with the clamping effect of the clamping felt is lower. Additionally, there is an improvement in the product haptic, based on the finer fiber structure and the absence of beads, and in the case of beads, these are unfiberized components, which, in addition to the coarser fibers, are significantly responsible for the haptic of conventional rock wool and are liable to contribute towards a higher dust producing behavior. Finally, based on the elastic behavior of the insulating material sheet of the invention, it is possible to undertake production with comparably lower excessive thickness.

Subsequently, the invention will be described and explained in detail, based on the drawing. The figures show:

Fig. 1 perspective view of a roll of mineral fibers with rolled out terminal segment,
Fig. 2 a typical fiber histogram of a conventional rock wool,
Fig. 3 a typical fiber histogram of a conventional glass wool, and
Fig. 4 a typical fiber histogram of the mineral wool according to the invention.

The insulation material sheet 1, shown in Fig. 1, consisting of mineral fibers, is partially rolled out, and the rolled out front terminal segment is designated with number 2. In the example shown, the insulation material sheet features a gross density of 13 kg/m3. The average geometric fiber diameter is of 3,2 µm and the binding agent portion is around 4,5 weight % referred to the fiber mass of the insulating material sheet. The insulation material

sheet shown is not laminated and is formed of mineral fibers, where the alkali/earth alkali relation is < 1. Alternately, also a laminated version is possible according to EP 1223 031, to which reference is now expressly being made.

As can be gathered from the front terminal segment 2, partially extracted from hub 3 of roll, the surface of the insulating material sheet, located inside hub, is provided with modular marking lines 5, aligned transversally to the longitudinal direction of the insulating material sheet and being disposed in uniform reciprocal distance ***d*** at the surface of said insulation material sheet. These marking lines, which may be disposed in different forms on the insulating material sheet, are formed by optically active lines, which are differently colored in relation to the insulation material sheet, being produced especially by heated marking cylinders. These marking lines 5 serve as cutting aids, so that simply the insulation material sheet may be cut at a predetermined length L of the terminal segment, and the cut is being made vertically towards the lateral borders 6 and parallel to the front border 7 of the insulation material sheet l, as indicated by a knife 8 in Fig. l. The knife is being conducted in the arrow direction 9 through the material, so that a terminal section with excessive measurement Ü is being produced, above 2 cm, for example, which is adequate as mineral fiber plate for clamping assembly between rafters. Alternately, the marking can also be made in the form of pictograms and similar procedures, as long as these may act as cutting aids.

In the example shown, the insulation material sheet l is rolled up with a compression rate of 1:4,5 to the roll. With the gross density of 13 kg/m3, the thermal conducting capacity of the insulating material section corresponds to thermal conductivity group 040.

The composition in weight % of the conventional, i.e. insulation material sheet formed from conventional rock wool, as well as insulation material sheet formed of conventional glass wool and the insulation material sheet according to the invention, results from Table 2, and the conventional rock wool as well as the insulation material sheet according to the invention, feature a fusion point of at least 1000 ° C according to DIN 4102, Part l7.

Table 2

Material	conventional rock wool	conventional glass wool	insulating material section according to invention
SiO_2	57,2	65	41,2
Al_2O_3	1,7	1,7	23,7
Fe_2O_3	4,1	0,4	5,6
TiO_2	0,3		0,7
CaO	22,8	7,8	14,4
MgO	8,5	2,6	1,5
Na_2O	4,6	16,4	5,4
K_2O	0,8	0,6	5,2
B_2O_3		5	
P_2O_5		0,15	0,75
MnO		0,3	0,6
SrO			0,5
BaO			0,34
Total	100	99,95	99,89

The composition is highlighted also by the fact that the fibers are biosoluble, i.e. they may be neutralized in a physiological milieu. The insulation material sheet with this composition is highlighted by intense resetting forces and corresponding rigidity. With comparable excessive measures as in the state of the art, sufficiently high resetting forces are attained at the assembly between rafters under compression, which insure a safe and firm retention of the insulation material plate also after longer periods of utilization.

Finally, figures 2 and 3 features for the conventional rock wool and glass wool, mentioned in the description, a typical fiber histogram of an insulation material sheet, and Fig. 4 indicates such a histogram of fibers of an insulation material sheet according to the invention.

From the following table 3 result preferred embodiments of the fibers according to invention (so-called IM wool) in comparison to conventional glass and rock wool fibers in

regard of the achieved clamping effect. Hereby GV stands for the loss due burning (and therefore the adhesive agent portion) and WLG stand for the thermal conductivity group according to DIN 18165. Measurement was hereby made by an internal examination norm for determining the clamping capability. Hereby embodiments with nominal densities from 140 to 160mm were compared. The device used for measurement comprises a fixed and adjustable rafter portion, which can be adjusted in distances of 700 mm, starting from 100 mm, to 1300 mm. The test samples are respectively examined with an overmeasure of 10 mm to the clamping felt. The measurement device was set to a clamping width of 1200 mm and the test sample was clamped between the rafters at a width of 1210 mm. If the felt does not clamp, the next smaller width is used at the measurement device and the test sample is cut to 1110 mm. The examination was continued until the test sample was clamped into the device resulting to the indicated figures for the clamping effect shown in table 3.

Table 3:

	bulk density [kg/m³]	nominal density	GV[%]	WLG	clamping effect
glass wool	13	140	4	040	800
rock wool	31	140	3	040	800
IM	14	140	4	040	1200
glass wool	21	160	4	035	700
rock wool	46	160	3	035	800
IM	23	160	4	035	1200